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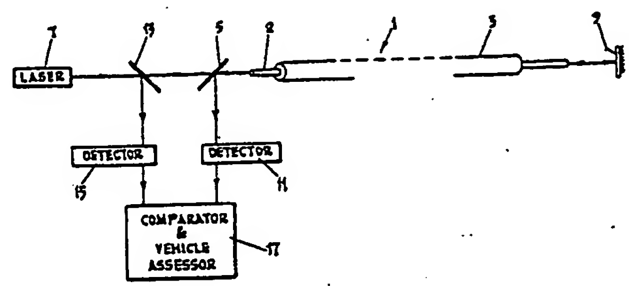
(54) Optical fibre sensor

(57) For sensing a moving body, including vehicles and personnel, a fibre-optic cable 1 is laid across the path of the moving body and light transmitted through the cable. Pressure of the body on the cable causes variations in the light transmission which can be detected. Different bodies or vehicles may be distinguished by their characteristic transmission loss patterns, axle weights may be measured, or speeds measured if the cable comprises a loop to produce two signals. In the latter case the light is not reflected back down the fibre by a mirror 9, as shown, but the detector is placed at the end of the fibre opposite the end by the source 7. The light may be chopped or modulated sinusoidally.



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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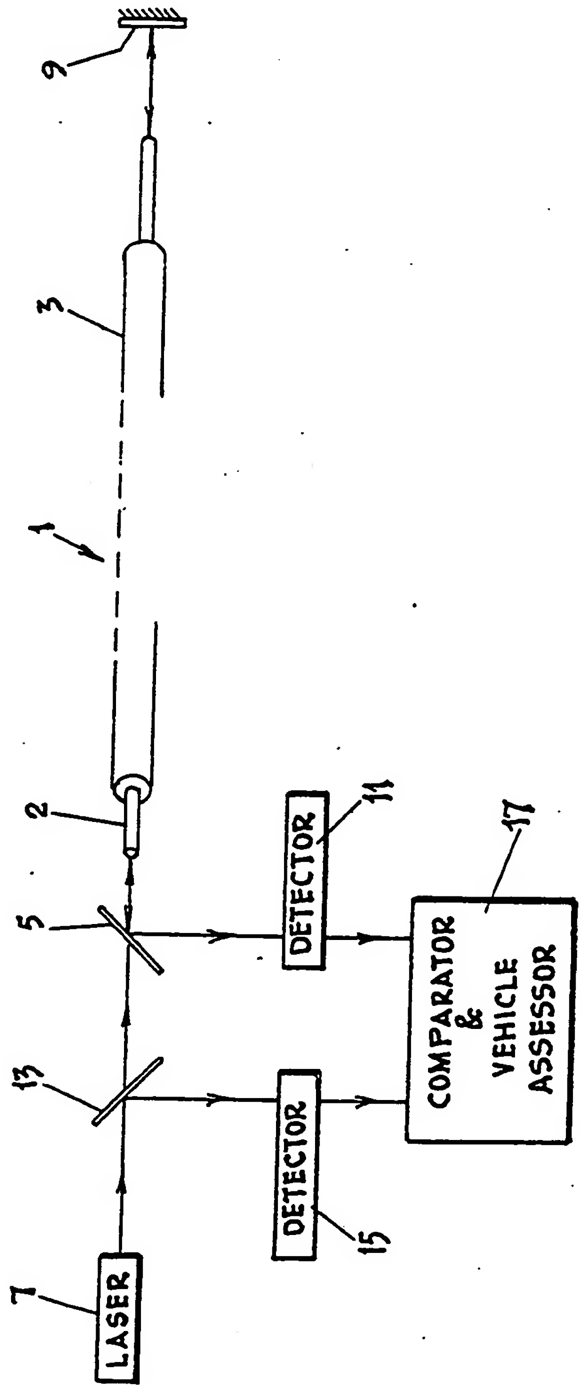
LASER
DETECTOR
DETECTOR
COMPARATOR & VEHICLE ASSESSOR
1
2
3
5
7
9
11
13
15
17

SPECIFICATION

Moving body sensing

This invention relates to moving body sensing equipment and systems incorporating such equipment.

An object of the present invention is to provide a simple, durable, pressure sensitive body detector operative in response to the weight of a body.

According to the present invention, moving-body sensing equipment comprises an optical fibre encased in a protective sheath, source means arranged to transmit light into an end of the fibre, and detection means responsive to the amount of light emerging from an end of the fibre to give an indication of a significant change in light transmission through the fibre when the fibre is subjected to a change in pressure due to the imposition or removal of a body compressing the fibre.

It will be appreciated that the term "light" as used in this specification includes all electromagnetic radiation which is transmissible in optical fibres.

The transmission of light through an optical fibre is impeded at any point in the fibre which is mechanically stressed, such as by compression due to the weight of a vehicle or other body bearing upon the cable. Moreover the degree of impedance to light transmission varies with the mechanical stress so that a measurement of the light transmission provides a measure of the mechanical load.

The detection means is preferably responsive to the amount of light that emerges from the fibre in relation to the amount of light that is transmitted into it.

The source means and the detection means may be at opposite ends or at the same end of the fibre, there being provided in the latter case reflecting means at the other end to reflect light emerging from the fibre back into the fibre towards the detection means.

The source means may include means for modulating the light transmitted into the fibre, the detection means then including filter means adapted to select light having this particular modulation.

The optical fibre may be one of a plurality in a cable providing parallel light transmission between the source means and the detection means.

The detection means may include means for distinguishing between different types of vehicles, and means for counting and recording vehicle numbers.

Where the optical fibre is laid in or on a vehicle carriageway transversely to the carriageway the source means and the detection means may be positioned at the side of the carriageway.

In a road vehicle sensing system according to the invention the detection means may include means for indicating and/or recording axle weights.

One embodiment of moving body sensing equipment in accordance with the invention will now be described, by way of example, with reference to the accompanying schematic diagram showing an application to a road vehicle detection system.

In the example shown schematically in the drawing, the fibre cable 1 comprises a single fibre 2 encased in a sheath 3, the sheath 3 being sufficiently tough to withstand the repeated passage of the wheels of road vehicles. Alternatively, the cable may have an inner sheath of conventional form and an outer sheath having the necessary toughness qualities. Clearly, different degrees of durability may be provided according to the nature, number and thickness of the sheaths. The strength of the sheathing must not, however, be such as to prevent any deformation of the optical fibre when subject to typical axle loads.

The cable is laid across a carriageway, preferably located in a groove or slot cut in the surface, or in a groove formed in a mat or pad laid on or fixed to the road surface. The cable must of course protrude sufficiently to permit deformation by a vehicle passing over it, or, alternatively, the walls of the groove may be of such sufficiently soft material that the cable takes the brunt of any load.

One end of the fibre 2 is coupled to a beam splitting device 5 to permit light passing in and out of the fibres to take different paths outside the cable. A source of light, preferably a laser 7, is arranged to transmit a beam of light through the beam splitting device and into the fibre at this end of the cable. The remote end of the cable is coupled to a reflector 9 which reflects any emergent light back down the cable to the source end. On passing through the beam splitting device the emergent light diverges from the path of the source beam and is intercepted by an optical detector 11.

A second beam splitting device 13 in the path of the source beam filters off a fraction of the beam to a second optical detector 15 the output of which provides a reference against which the beam returning from transit of the cable is compared in a comparator circuit 17.

The relation between the two detector outputs, in particular their ratio, can be quantified into a number of bands to provide group indications of axle loadings. For this purpose the comparator circuit 17 imposes various degrees of amplification on the main detector (11) output signal, the amplified signals then being compared with the reference detector (15) output in respective comparator circuits. The lowest-gain circuit to trigger its comparator then indicates the appropriate band in which the main detector (11) output falls.

Since the magnitude of the output signal from detector 11 will vary inversely with the mechanical load on the cable, the lightest load will be indicated by 'tripping' of the comparator in the minimum-gain circuit. This comparator can also be used as a threshold detector for the indication of the passage of any significant vehicle.

A general traffic count can be made by a counter in the circuit 17 operated by this 'lightest-load' threshold detector.

It may be desirable to provide a positive identification between the output signal of the optical detector 11 and the original beam entering the fibre, by modulating the beam and filtering the modulated signal at the detector 11, which then constitutes part of a receiver. Thus the beam source may be

chopped, or modulated sinusoidally, and a tuned circuit in the receiver arranged to select only the modulated component of the received light.

In use, the equipment may be operated continuously, e.g. on a public highway, the cable being partially buried in a slot in the road surface. The transmitting and receiving equipment may be mounted by the side of the road together with automatic recording and/or visual indication equipment.

Alternatively, the equipment may be used in a testing station where a vehicle may be directed over the cable and a record made of the loadings on the various axles.

In a modification of the equipment described above, the light source and sensor may be at opposite ends of the cable with no reflector employed. Higher levels of received signal will of course be obtained with this arrangement for the same length of cable. However, active equipment is required at both ends of the cable and access may be difficult.

An alternative arrangement uses a loop of cable crossing the carriageway twice, the source and receiver equipment again being at the same location but at opposite ends of the cable. With this arrangement, if the 'go' and 'return' lengths of the cable are parallel and spaced a predetermined distance apart, a speed indication can be obtained by timing the pulses of light suppression.

Alternative forms of cable may be employed, for example using multi-fibre cores. A less definite result may be obtained in this way since there will be a range of deformation of the fibres and an averaging effect. There is also an increased risk of damage to the fibres in a multi-fibre cable by close engagement with each other.

Fibres used in this invention preferably have large cores with low minimal aperture.

In an alternative vehicle sensing system, a fibre is supported between adhesive tapes one of which has a rough surface engaging the fibre to accentuate the attenuation effect of mechanical load. The outer faces of the tapes may be coloured to indicate the 'road' and 'face up' surfaces.

In the embodiment mentioned above employing a mat incorporating the fibre, the mat may be of similar form and construction to that described in our Patent No. 1292595.

The cable employed in this invention may be of a form described in co-pending patent application No. 7930093.

In an alternative application of the invention an optical fibre cable is disposed across a pedestrian path to detect their passage. A typical such application would employ a cable extending across a pedestrian crossing in a mat or groove in the road. The cable would of course have to cross and re-cross at intervals smaller than the length of a 'minimum' footstep to ensure that a footstep could not be missed, and at a sufficient number of intervals to ensure that the cable could not be stepped over completely.

CLAIMS

1. Moving-body sensing equipment comprising an optical fibre encased in a protective sheath, source means arranged to transmit light into an end of the fibre, and detection means responsive to the amount of light emerging from an end of the fibre to give an indication of a significant change in light transmission through the fibre when the fibre is subjected to a change in pressure due to the imposition or removal of a body compressing the fibre.

2. Equipment according to Claim 1, wherein said detection means is responsive to the amount of light that emerges from the fibre in relation to the amount of light that is transmitted into it.

3. Equipment according to Claim 1 or Claim 2, wherein said source means and said detection means are at opposite ends of the fibre.

4. Equipment according to Claim 1 or Claim 2, wherein said source means and said detection means are at the same end of the fibre, there being provided reflecting means at the other end to reflect light emerging from the fibre back into the fibre towards said detection means.

5. Equipment according to any preceding claim wherein said source means includes means for modulating the light transmitted into the fibre and said detection means includes filter means adapted to select light having this particular modulation.

6. Equipment according to any preceding claim wherein said optical fibre may be one of a plurality in a cable providing parallel light transmission between said source means and said detection means.

7. Equipment according to any preceding claim, wherein said detection means includes means for distinguishing between different vehicle types.

8. Equipment according to any preceding claim, wherein said detection means includes means for counting and recording vehicle numbers.

9. A vehicle sensing system including equipment according to any preceding claim, wherein said optical fibre is laid in or on a vehicle carriageway transversely to the carriageway said source means and said detection means being positioned at the side of the carriageway.

10. A road vehicle sensing system according to Claim 9, wherein said detection means includes means for indicating and or recording axle weights.

11. A road vehicle sensing system substantially as hereinbefore described with reference to the accompanying drawing.

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